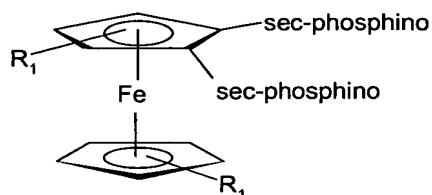


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Claims:

1. A compound of the formula I in the form of a racemate, a mixture of diastereomers or an essentially pure diastereomer,

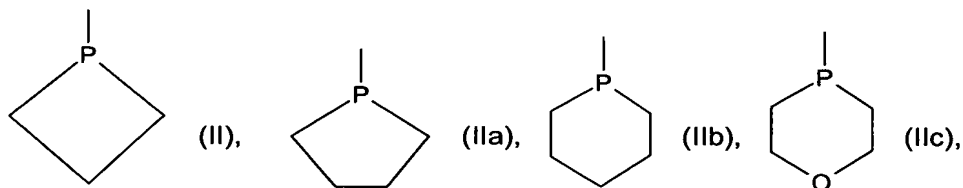


(I),

where

R_1 is a hydrogen atom or C_1 - C_4 -alkyl and at least one sec-phosphine group is an unsubstituted or substituted cyclic phosphino group, or a phosphonium salt thereof having one or two monovalent anions or one divalent anion.

2. The compound as claimed in claim 1, wherein the cyclic sec-phosphino corresponds to the formula II, IIa, IIb or IIc,



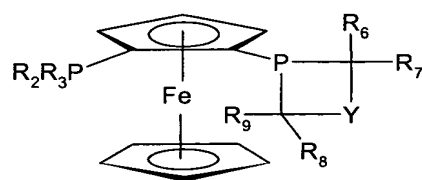
which are unsubstituted or substituted by one or more -OH, C_1 - C_8 -alkyl, C_4 - C_8 -cycloalkyl, C_1 - C_6 -alkoxy, C_1 - C_4 -alkoxy- C_1 - C_4 -alkyl, phenyl, C_1 - C_4 -alkyl- or C_1 - C_4 -alkoxyphenyl, benzyl, C_1 - C_4 -alkyl- or C_1 - C_4 -alkoxybenzyl, benzyloxy, C_1 - C_4 -alkyl- or C_1 - C_4 -alkoxybenzyloxy or C_1 - C_4 -alkylidenedioxyl groups.

3. The compound as claimed in claim 2, wherein substituents are present in one or both α positions relative to the P atom.

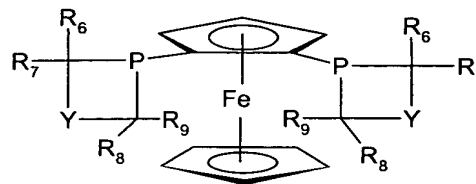
4. The compound as claimed in claim 1, wherein the compound of the formula I corresponds to the formula III or IV,

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(III),

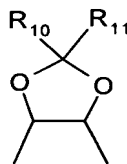


(IV),

where

R_2 and R_3 are each, independently of one another, a hydrocarbon radical which has from 1 to 20 carbon atoms and is unsubstituted or substituted by halogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, di- C_1 - C_4 -alkylamino, $(C_6H_5)_3Si$, $(C_1-C_{12}\text{-alkyl})_3Si$, or $-CO_2-C_1-C_6\text{-alkyl}$,

Y is $-CH_2-$, $-CH_2CH_2-$, $-CH_2CH_2CH_2-$, $-CH(OH)CH(OH)-$, $-CH(OC_1-C_4\text{-alkyl})CH(OC_1-C_4\text{-alkyl})-$ or a radical of the formula

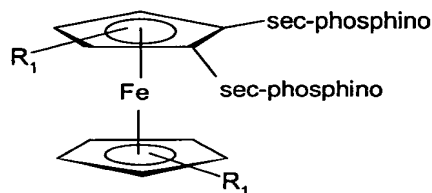


R_6 , R_7 , R_8 and R_9 are each, independently of one another, H, C_1 - C_4 -alkyl or benzyl, and at least one of the radicals R_6 , R_7 , R_8 and R_9 is C_1 - C_4 -alkyl, benzyl or $-CH_2-O-C_1-C_4\text{-alkyl}$ or $-CH_2-O-C_6-C_{10}\text{-aryl}$,

R_{10} is H or C_1 - C_4 -alkyl and

R_{11} is C_1 - C_4 -alkyl.

5. A process for preparing compounds of the formula I in the form of racemates, mixtures of diastereomers or essentially pure diastereomers,



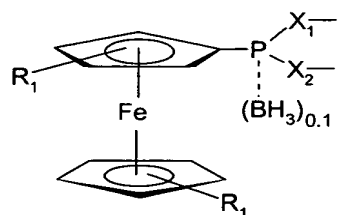
(I),

where

R_1 is a hydrogen atom or C_1 - C_4 -alkyl and at least one sec-phosphino is an unsubstituted or substituted cyclic phosphino group, which comprises the steps

a) reaction of a compound of the formula V

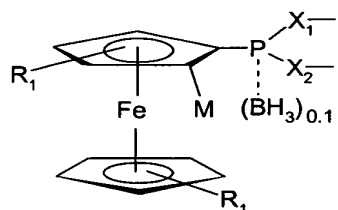
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(V),

where

X_1 and X_2 are each, independently of one another, O or N and C-bonded hydrocarbon or heterohydrocarbon radicals are bound to the free bonds of the O and N atoms, with at least equivalent amounts of a lithium alkyl, a magnesium Grignard compound or an aliphatic Li sec-amide or $X_3\text{Mg}$ sec-amide to form a compound of the formula VI,

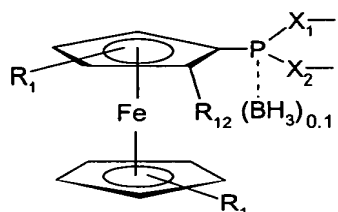


(VI),

where

M is $-\text{Li}$ or $-\text{MgX}_3$ and X_3 is Cl, Br or I,

b) reaction of the compound of the formula VI with at least equivalent amounts of a di-sec-aminophosphine halide, a dialkoxyphosphine halide, di-sec-amino- $\text{P}(\text{O})$ halide, dialkoxy- $\text{P}(\text{O})$ halide or PCl_3 or PBr_3 to form a compound of the formula VII



(VII),

where

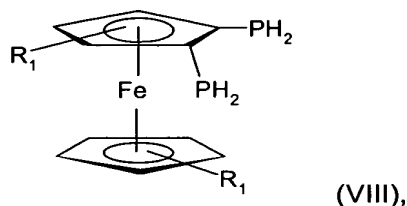
R_{12} is $-\text{PCl}_2$, $-\text{PBr}_2$, $\text{di}(\text{sec-amino})\text{P}-$, $\text{dialkoxyP}-$, $\text{di-sec-amino-P}(\text{O})-$, $\text{dialkoxy-P}(\text{O})-$, and

b1) removing any borane group present from a compound of the formula VII, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 or di-sec-amino or dialkoxy by means of HCl or HBr to form a $-\text{PCl}_2$ group or $-\text{PBr}_2$ group and then hydrogenating the $-(\text{O})\text{PCl}_2$ groups, $-(\text{O})\text{PBr}_2$ groups, $-\text{PCl}_2$ groups or $-\text{PBr}_2$ groups

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to form a compound of the formula VIII or

b2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 or di-sec-amino or dialkoxy from a compound of the formula VII by means of HCl or HBr to form a - PCl_2 group or - PBr_2 group and then hydrogenating the - $(O)PCl_2$ groups, - $(O)PBr_2$ groups, - PCl_2 groups or - PBr_2 groups and then removing the borane group to form a compound of the formula VIII,



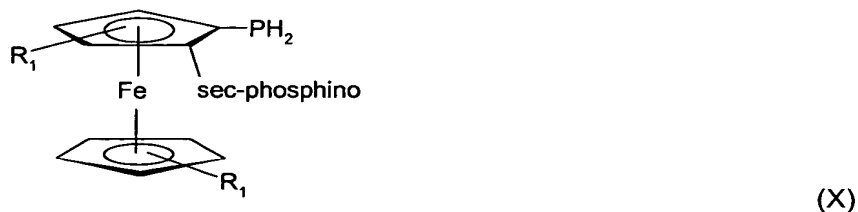
or

c) reaction of a compound of the formula VI with a sec-phosphine halide to form a compound of the formula IX,



c1) removing any borane group present from a compound of the formula IX, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 by means of HCl or HBr to form a - PCl_2 group or - PBr_2 group and then hydrogenating the - PCl_2 groups or - PBr_2 groups to form a compound of the formula X or

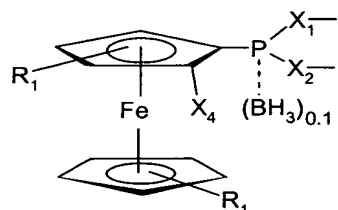
c2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 from a compound of the formula IX by means of HCl or HBr to form a - PCl_2 group or - PBr_2 group and then hydrogenating the - PCl_2 groups or - PBr_2 groups and then removing the borane group to form a compound of the formula X



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or

d) reaction of a compound of the formula VI with a halogenating reagent to form a compound of the formula XI

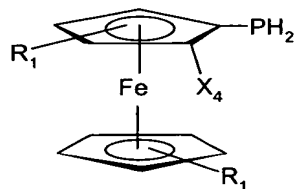


(XI),

where X_4 is Cl, Br or I,

d1) removing any borane group present from a compound of the formula XI, then splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 by means of HCl or HBr to form a $-PCl_2$ group or $-PBr_2$ group and then hydrogenating the $-PCl_2$ group or $-PBr_2$ group to form a compound of the formula XII or

d2) splitting off the radicals (hetero)hydrocarbon- X_1 , (hetero)hydrocarbon- X_2 or X_1 -(hetero)hydrocarbon- X_2 from a compound of the formula XI by means of HCl or HBr to form a $-PCl_2$ group or $-PBr_2$ group and then hydrogenating the $-PCl_2$ groups or $-PBr_2$ groups and then removing the borane group to form a compound of the formula XII



(XII)

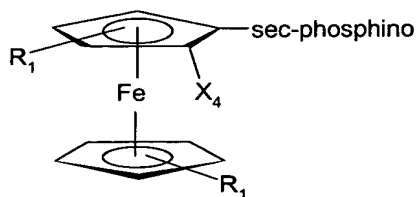
and

d3) reacting the compound of the formula XII with a metalated sec-phosphide to form a compound of the formula X,

e) reaction of the compound of the formula VII with at least 2 equivalents and of the compound of the formula X with at least 1 equivalent of a cyclic sulfate or an open-chain disulfonate to produce compounds of the formula I in which one or both sec-phosphino groups are cyclic sec-phosphino or

f) reaction of a compound of the formula XII with at least 1 equivalent of a cyclic sulfate or an open-chain disulfonate to produce compounds of the formula XIII,

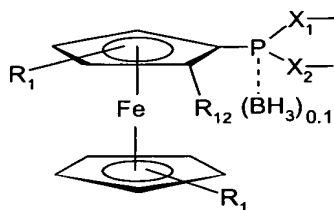
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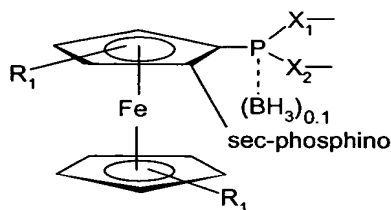
(XIII)

where sec-phosphino is cyclic sec-phosphino which may, if appropriate, be protected by BH_3 , and then reaction of a compound of the formula XIII with at least 1 equivalent of a lithium alkyl and then with at least 1 equivalent of a sec-phosphine halide to form a compound of the formula I.

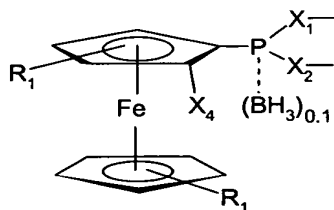
6. A compound of the formula VII, IX and XI,



(VII),



(IX), and



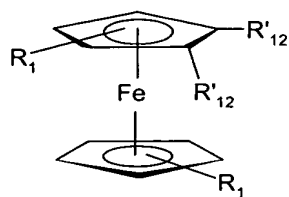
(XI),

where

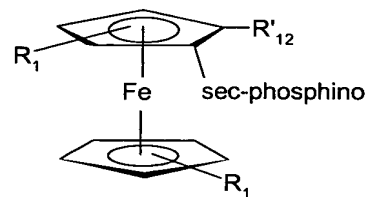
X_1 and X_2 are each, independently of one another, O or N and C-bonded hydrocarbon or heterohydrocarbon radicals are bound to the free bonds of the O and N atoms and R_1 , R_{12} and X_4 are as defined in claim 5.

7. A compound of the formula VIII, X or XII,

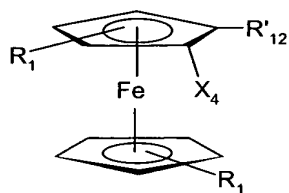
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(VIII),



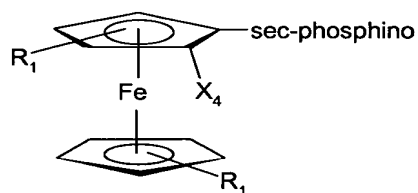
(X), and



(XII),

where R'_{12} is $-PCl_2$, $-PBr_2$ or $-PH_2$ and R_1 and X_4 are as defined in claim 5.

8. A compound of the formula XIII



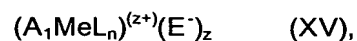
(XIII),

where R_1 and X_4 are as defined in claim 5 and sec-phosphino is cyclic sec-phosphino.

9. A complex of a metal selected from the group consisting of the group 8 transition metals with compounds of the formula I as ligands.

10. The metal complex as claimed in claim 9, wherein the group 8 transition metal is ruthenium, rhodium or iridium.

11. The metal complex as claimed in claim 9, characterized in that it corresponds to the formula XIV or XV,



where A_1 is a compound of the formula I,

L represents identical or different monodentate, anionic or nonionic ligands, or L_2 represents

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identical or different bidentate, anionic or nonionic ligands;

n is 2, 3 or 4 when L is a monodentate ligand or n is 1 or 2 when L is a bidentate ligand;

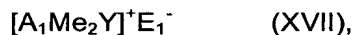
z is 1, 2 or 3;

Me is a metal selected from the group consisting of Rh, Ir and Ru; with the metal having the oxidation state 0, 1, 2, 3 or 4;

E⁻ is the anion of an oxo acid or complex acid; and

the anionic ligands balance the charge of the oxidation state 1, 2, 3 or 4 of the metal.

12. The metal complex as claimed in claim 9, characterized in that it corresponds to the formula XIII or XIV,



where

A₁ is a compound of the formula I;

Me₂ is rhodium or iridium;

Y represents two olefins or diene;

Z is Cl, Br or I; and

E₁⁻ is the anion of an oxo acid or complex acid.

13. The use of metal complexes as claimed in claim 9 as homogeneous catalysts for preparing chiral organic compounds by asymmetric addition of hydrogen, boron hydrides or silanes onto a carbon-carbon or carbon-heteroatom multiple bond in prochiral organic compounds or asymmetric addition of carbon nucleophiles or amines onto allyl compounds.

14. A process for preparing chiral organic compounds by asymmetric addition of hydrogen, boron hydrides or silanes onto a carbon-carbon or carbon-heteroatom multiple bond in prochiral organic compounds or asymmetric addition of carbon nucleophiles or amines onto allyl compounds in the presence of a catalyst, characterized in that the addition reaction is carried out in the presence of catalytic amounts of at least one metal complex as claimed in claim 9.

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